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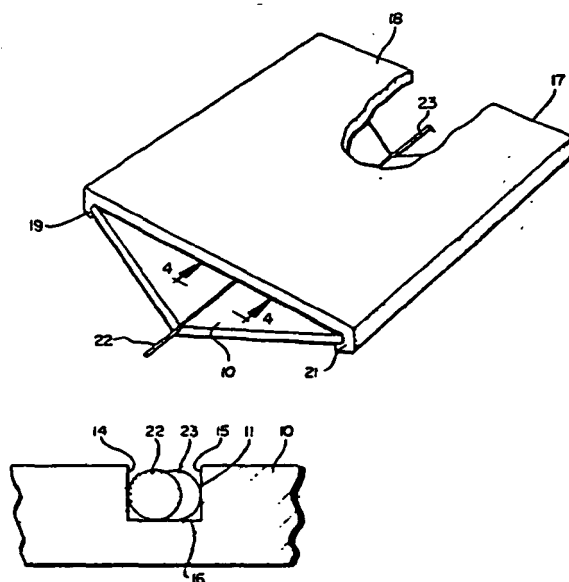
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⑤④ **Optical fiber splice.**

⑤⑦ A connector for securing the ends of a pair of optical waveguide fibers in optical alignment comprises a resilient base having a U-shaped groove adapted to receive the ends of the fibers and a clamp for deforming the base in a manner such that the sidewalls of the groove are brought into compressive engagement with the fibers. The compressive forces exerted by the walls of the groove bring the fibers into optical alignment and also secure the fibers against axial and lateral displacement.



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OPTICAL FIBER SPLICEFIELD OF THE INVENTION

5 The present invention relates to a method and apparatus for securing the ends of a pair of optical waveguide fibers in optical alignment.

BACKGROUND OF THE INVENTION

10 It is known that thin light-transmitting fibers formed of glass, plastic or the like, have certain inherent advantages over metallic conductors for transmission of signals in the telecommunications industry. Because of the great bandwidth which such fibers possess, a single fiber can transmit information at a higher rate than a metallic conductor many times its size, with consequent
15 savings in material and installation costs.

Also because of their nature, however, the use of such fibers presents certain practical problems which are not present in systems employing metallic conductors. In forming a splice between two metallic
20 conductors the main problem is one of assuring electrical continuity, and the physical orientation of the ends of the conductors is usually immaterial. On the other hand, in forming a splice between two optical fibers, the ends of the fibers must be
25 brought into precise axial and angular alignment in order to avoid unacceptably high loss of light transmission from one fiber to the other. The problem of obtaining the necessary degree of precision in aligning optical fibers is complicated
30 by the fact that the fibers are very small, typically having a diameter on the order of 0.0127 centimeters, and fragile in nature. In practice, the problems

encountered in joining such fibers are further complicated by the fact that the splice must be made in the field by service or installation personnel without the aid of intricate or complex equipment. Further, in order to make a system based on such fibers economically feasible on a wide scale, any connector used in splicing optical fibers must be inexpensive and easy to manufacture.

Several connectors intended for splicing optical fibers are known. In some of these devices, e.g., those shown in U.S. Patents 3,768,146, issued October 30, 1973, Frank A. Braun, et al; 4,057,448, issued November 8, 1977, Calvin M. Miller; and 4,077,702, issued March 7, 1978, Dieter Künze, et al, the ends of the fibers to be spliced are inserted into a connector such as a sleeve, designed to bring the ends into proper alignment, and the splice is completed by cementing the ends of the fibers or crimping the connector. In another technique, as shown in U.S. Patents 3,912,574, issued October 14, 1975, Allen H. Cherin, et al; 3,984,172, issued October 5, 1976, Calvin M. Miller; and 4,029,390, issued June 14, 1977, Edwin L. Chinnock, et al, the ends of the connectors are placed in precisely dimensioned V-shaped or circular grooves designed to bring the fibers into axial alignment, and a cover plate or the like is affixed to hold the fibers in position. While these devices have met with varying degrees of success, they still have certain practical shortcomings. Those employing sleeves present problems in inserting the fine fiber into the connecting sleeve, while those employing grooves require precise dimensions and careful attention to insure that no misalignment occurs when the cover plate is affixed. In addition, those that depend on cement for securing the connection require that the

splice remain undisturbed while the cement cures.

U.S. Patent 4,123,138, issued October 31, 1978, Robert J. Morrison, discloses a connector employing a deformable base having therein a hole
5 precisely conforming to the diameter of the fibers to be joined. By bending the base along a longitudinal axis parallel to the hole, the hole is deformed sufficiently to permit the insertion, into opposite
10 ends of the hole, of the ends of the fibers to be spliced, whereupon the base is permitted to return to its normal undeformed condition. Despite the enlargement of the hole which may occur on deformation of the base, the connector still presents the problem of inserting a fine fiber into a small
15 hole and assuring that the ends of the fibers are properly adjacent.

SUMMARY OF THE INVENTION

In accordance with the invention there are provided a simple method and an inexpensive
20 easy-to-use connector for use in making accurately aligned and reliable splices between the ends of a pair of optical fibers.

In its broadest context, the connector of the invention comprises resilient means having a groove
25 defined in part by opposed sidewalls, the groove being adapted to receive loosely the ends of a pair of optical fibers to be spliced. The connector also comprises means for deforming the resilient means in order to cause the sidewalls of said groove to apply
30 a compressive force to the fibers which brings them into alignment and also secures them within the groove.

In a preferred embodiment of the connector of the invention, the groove is formed in a generally

5 rectangular sheet of deformable material, suitably of
substantially uniform thickness, the groove itself
acting as a score line creating a fold axis about
which the base can be folded in a direction tending
to narrow the opening at the top of the groove. The
connector also includes clamp means for maintaining
the base in its deformed condition with the fiber
ends within the groove and the base folded
sufficiently to cause the sidewalls of the groove to
10 exert compressive forces on the sides of the fibers.
In one specific embodiment, the clamp means engages
two opposite edges of the base parallel to and
substantially equidistant from the groove. In
another embodiment, the base is provided with a pair
15 of upstanding ribs located on either side of and
parallel to the groove, and the clamp comprises a
hollow member having a longitudinal slot into which
the deformed base is inserted with the upstanding
ribs in contact with the edges of the slot.

20 The method of the invention involves placing
the ends of the fibers in a generally U-shaped groove
formed in a resilient base means which is deformable
along a fold axis running longitudinally of the
groove. With the fiber-ends in adjacent or abutting
25 relationship in the groove, the base is deformed
along the fold axis in a direction to narrow the
width of the entrance to the groove, thereby causing
the walls of the groove to exert a force on the
fibers which not only secures the ends of the fibers
30 in the connector but also automatically centers the
ends thereof both angularly and axially. Further,
because the method produces inward deformation of the
sides of the groove, the width of the undeformed
groove can be made substantially larger than the
35 diameter of the fibers, thereby facilitating
installation of the fiber ends within the groove.

The invention will be better understood from the following detailed description thereof taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

5 In the drawings, like numerals are used to identify the same elements in the several figures, in which:

10 FIGURE 1 is a perspective view of a typical base forming a part of the connector of the invention, with the ends of a pair of fibers in adjacent relationship in a groove in the base, prior to deformation of the base;

15 FIGURE 2 is a perspective view of a finished splice using the connector of the invention, showing a clamp holding the base of FIGURE 1 in a deformed condition, a portion of the clamp being torn away to show the interior of the connector;

20 FIGURE 3 is an enlarged partial section along the line 3-3 of FIGURE 1, showing the fiber ends in position in the groove before deformation of the base;

FIGURE 4 is an enlarged partial section along the line 4-4 of FIGURE 2, showing the base in a deformed condition, with the sides of the groove exerting a centering force on the fiber ends;

25 FIGURE 5 is a perspective view of an alternative embodiment of a base used in the invention, having two upstanding ribs parallel to and on opposite sides of the groove in which two fiber ends have been inserted, a portion of one of the ribs
30 being torn away;

FIGURE 6 is a perspective view of a clamp suitable for holding the base of FIGURE 5 in a deformed condition;

FIGURE 7 is an enlarged partial section along

the line 7-7 of FIGURE 5 showing the fiber ends in position in the undeformed base; and

FIGURE 8 is an elevational view of the base of FIGURE 5 and the clamp of FIGURE 6 in an assembled condition.

DETAILED DESCRIPTION OF THE INVENTION

As shown in Figures 1 and 2, in one embodiment the connector of the invention employs a generally planar rectangular base 10 formed of an appropriately resilient material, the base having a groove 11 which extends across the base in a direction generally parallel to and spaced from two opposite edges 12 and 13 of the base. As shown in Figure 3, groove 11 is suitably rectangular or generally U-shaped in cross-section, having a pair of opposed, generally parallel sidewalls 14 and 15 interconnected by bottom wall 16, the upper edges of the sidewalls defining an entrance to the groove. The dimensions of the groove and fibers shown in the figures are not to scale, being enlarged to facilitate illustration. In a preferred embodiment, base 10 has a substantially uniform thickness, i.e., the upper and lower surfaces thereof are defined by generally parallel planes. Accordingly, groove 11 reduces the thickness of base 10 and creates a fold line or axis extending longitudinally of the groove, about which base 10 can be folded to assume the inverted V-shaped configuration shown in Figure 2. It should be understood, however, that base 10 need not have a uniform thickness, provided that it can be folded or otherwise deformed along the length of groove 11 to cause the sidewalls of the groove to provide the desired clamping and centering forces on the fibers, discussed below.

Also shown in Figure 2 is a clamp 17 comprising a suitably dimensioned rectangular plate 18, to opposite edges of which are affixed a pair of depending inwardly opening channels 19 and 21 which engage the edges 12 and 13 of base 10 and maintain the base in the deformed condition shown in Figure 2.

In forming a splice using the connector of the invention, the ends of two optical fibers 22 and 23 to be joined are placed in abutting or adjacent relationship in approximately the middle of groove 11, the exact location of the ends of the fibers in the groove being immaterial. Opposed edges 12, 13 of base 10 are then folded about the groove as an axis in a direction to narrow the entrance of the groove and to clamp the fibers therein, as shown in Figure 4. Clamp 17 is then assembled over the deformed base with edges 12, 13 of the base engaging channels 19, 21 of the clamp. By making base 10 of an elastically deformable sheet material having a tendency to return to its normal planar state, edges 12, 13 of base 10 will exert a force against channels 19, 21 sufficient to maintain the integrity of the structure. If it is desired for any reason to disassemble the joint, clamp 17 can be easily moved to disengage channels 19, 21 from the edges of base 10, thereby permitting base 10 to be flattened sufficiently to permit removal of the fiber ends.

It will be seen in Figures 3 and 4, that the normal undeformed width, i.e., the distance between walls 14 and 16, of groove 11 is greater than the diameter of fibers 22 and 23, thereby facilitating the insertion of the fibers into the groove. When base 10 is folded or deformed, however, opposite sidewalls 14, 16 of the groove are inclined towards each other sufficiently to come into contact with and to exert a compressive force on the fibers. As shown

in Figure 4, the radial force F_c exerted on the fibers by contact with each sidewall of the groove can be resolved into a horizontal component F_1 which tends to center each fiber laterally within the groove and a downwardly directed vertical component F_2 which forces the fiber into contact with bottom wall 16 of the groove. Thus, although the fibers are not aligned when originally inserted in undeformed groove 11, as shown in Figure 3, deformation of base 10 not only brings the fibers into axial alignment but also grips them with sufficient force to provide a strain relief and to prevent accidental displacement during normal handling. As will be evident to those skilled in the art, however, the gripping and aligning forces should not be sufficient to deform the fibers to the extent that the light transmitting ability thereof is adversely affected.

During assembly of the connector of the invention, an index matching cement can be applied to joint 26 between fibers 22 and 23, if a non-detachable joint is desired. In any event, it will be seen that the assembly can be completed immediately after application of the cement without waiting for the cement to harden or cure, since the ends of the fibers are maintained by the connector in properly aligned condition during such hardening or curing.

In another embodiment of the invention, which differs from that previously described principally in the means used to maintain the base in a deformed or V-shape, base 30 (Figure 5) is provided with a pair of upstanding ribs 31 and 32 parallel to and positioned on opposite sides of groove 33. Clamp 34 (Figure 6) is used with base 30 and comprises a tubular or box-like member 36 having open ends 37 and a longitudinally extending slot 38 having a width

which is less than the distance between outer faces 39 and 40 of upstanding ribs 31 and 32. For assembly of the elements shown in Figures 5 and 6, after insertion of fibers 41 and 42 into groove 33, base 30 is folded along groove 33 to a V-shape as shown in Figure 8 and inserted into open end 37 of clamp 34 with upstanding ribs 31 and 32 in contact with edges 43 and 44 of slot 37, the lower portions 46 and 47 of which may be chamfered as shown to provide an appropriate bearing surface for maintaining the base 30 in a deformed condition. In all other respects, the connector shown in Figures 5-8 and the manner of its use correspond with those of the embodiment of Figure 2.

The groove, e.g., 11 or 33, used in the connector of the invention preferably has a width which is 1.0-1.5 times the depth thereof. A groove so dimensioned can be used to splice a variety of different fiber sizes without adjustment, and thus reduces the number of different sizes of connectors which must be stocked for making splices. Further, since in general the fibers which can be spliced with a given connector have diameters which are substantially smaller than the width of the groove, insertion of the fibers into the groove is easily accomplished in the field without the necessity for using auxiliary equipment such as magnifiers or microscopes.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom as modifications will be obvious to those skilled in the art.

CLAIMS

WHAT IS CLAIMED IS:

5 1. A connector for securing the ends of a pair of optical fibers in optical alignment comprising:

resilient means having a groove for loosely receiving the ends of said optical fibers in unaligned relation, said groove being defined in part by opposed sidewalls; and

10 means for deforming said resilient means to move said walls into compressive engagement with said optical fibers, said walls moving the ends of said optical fibers into optical alignment and securing said optical fibers in said groove.

15 2. A connector in accordance with claim 1 wherein said walls combine to exert compressive forces on said optical fibers when said resilient means is deformed, said compressive forces having first opposing force components for centering said optical fibers in said groove and second cooperating force components for bottoming said optical fibers in said groove.

25 3. A connector in accordance with claim 2 wherein said groove has a generally U-shaped cross-sectional configuration defined by said walls and a bottom wall extending therebetween, said sidewalls defining an entrance to said groove.

4. A connector for securing a pair of optical waveguide fibers in optical alignment comprising:

30 a base having a groove adapted to receive, in adjacent relationship, an end of each of said pair of fibers,

said groove being defined in part by a pair of opposed generally parallel sidewalls,

said base being deformable about a fold axis extending longitudinally of said groove, and

5 clamp means for deforming said base, such that said sidewalls secure said ends in aligned relationship.

5. A connector in accordance with claim 4 wherein said base is elastically deformable along the length of said groove.

10 6. A connector in accordance with claim 4 wherein said base is generally rectangular in outline and is provided with a pair of generally parallel upstanding ribs situated on opposite sides of and generally parallel to said groove, and said clamp exerts a force on said ribs, causing said base to
15 deform along said fold axis.

20 7. A connector in accordance with claim 6 wherein said clamp has a box-like construction with open opposing ends permitting the insertion therein of said base, said clamp having a longitudinally extending slot with opposed edges adapted to engage said upstanding ribs and to exert said deforming force thereon.

25 8. A connector in accordance with claim 7 wherein the width of said groove is 1.0-1.5 times the depth thereof.

9. A method for joining a pair of optical waveguide fibers comprising the steps of:

providing a base having a groove adapted to receive said fibers,

30 said groove having a pair of opposed sidewalls, said base being deformable about a fold axis extending longitudinally of said groove,

placing an end of each of said fibers in adjacent relationship in said groove, and

35 folding said base about said axis to cause said sidewalls to exert a clamping force on said ends

which aligns and secures them in aligned relationship.

10. A method in accordance with claim 9 including the additional step of applying an index matching adhesive to said adjacent ends to provide a permanent joint.
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FIG. 1

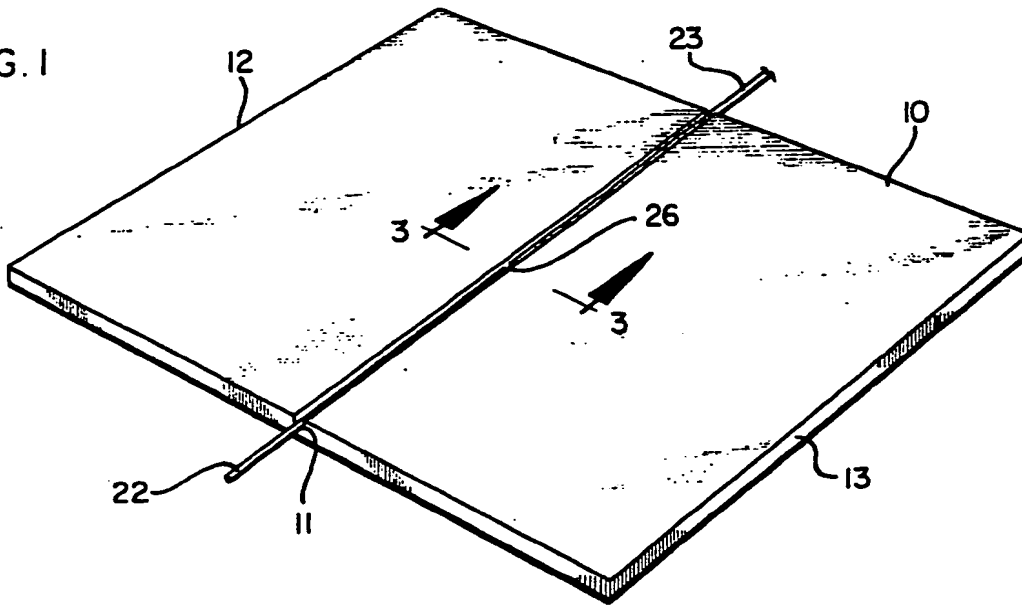


FIG. 2

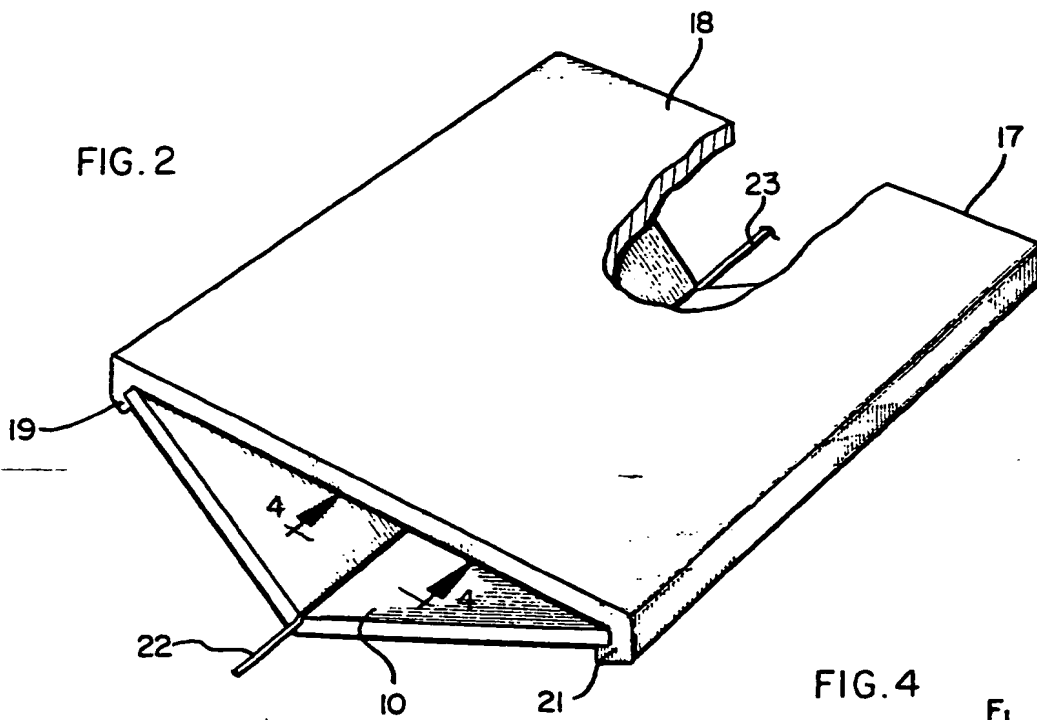


FIG. 3

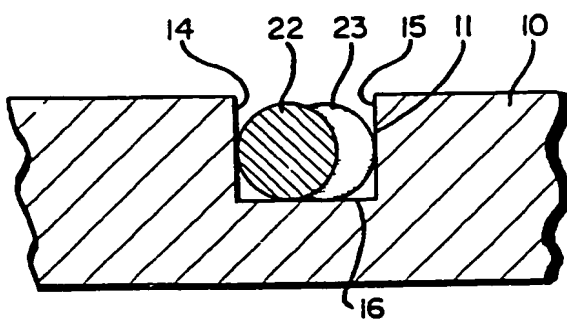


FIG. 4

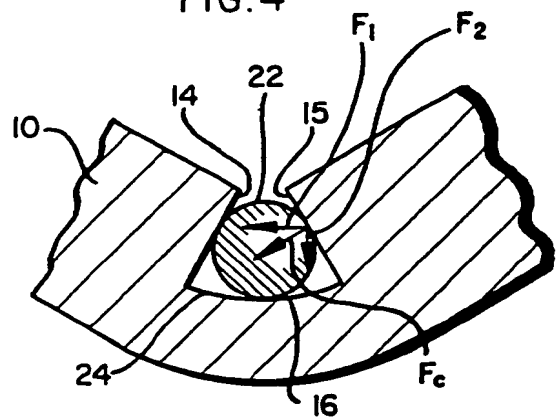


FIG. 5

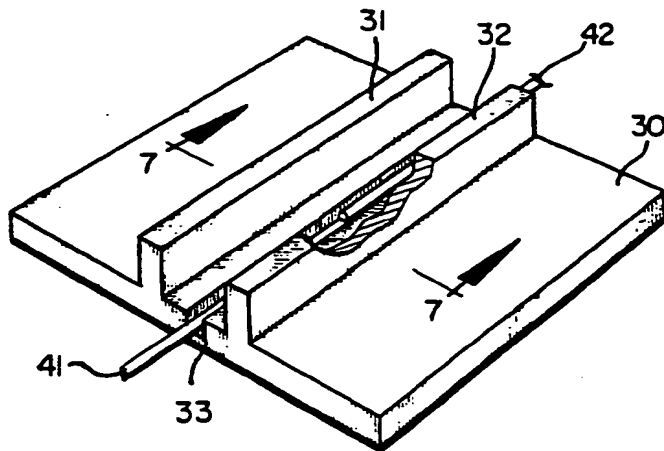


FIG. 6

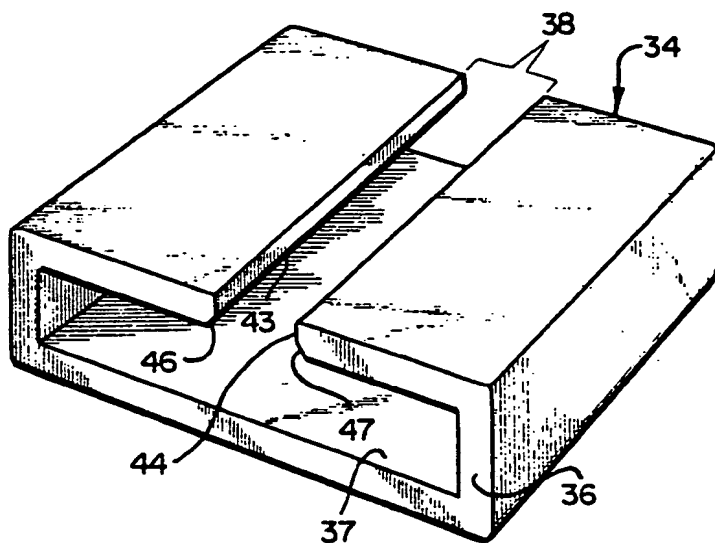


FIG. 7

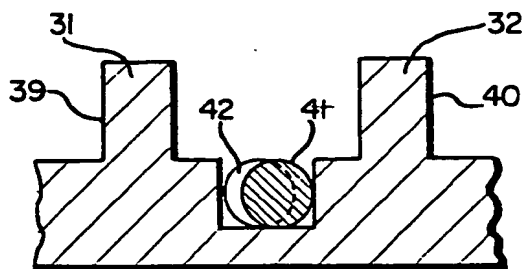
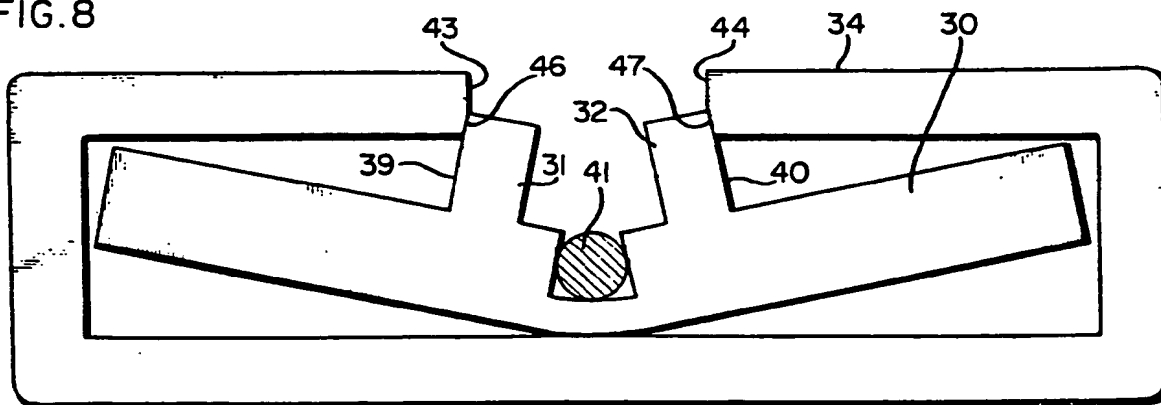


FIG. 8





European Patent
Office

EUROPEAN SEARCH REPORT

0065096

Application number

EP 82 10 2571.5

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
Y	<u>US - A - 4 205 898</u> (ITT INDUSTRIES, INC.) * column 1, lines 28 to 44 *	1,2, 4,5	G 02 B 7/26
Y	<u>DE - A1 - 2 733 167</u> (LICENTIA PATENT- VERWALTUNGS-GMBH) * page 5, paragraph 3 to page 6, paragraph 1 *	1,2, 4,5	
D,A	<u>US - A - 4 057 448</u> (BELL TELEPHONE LABORATORIES INCORPORATED) * column 1, lines 43 to 68 *	1-3, 10	TECHNICAL FIELDS SEARCHED (Int.Cl. 3)
D,A	<u>US - A - 3 768 146</u> (BELL TELEPHONE LABORATORIES INCORPORATED) * column 1, lines 24 to 39 *	1,2, 4,10	G 02 B 5/00 G 02 B 7/26
A	<u>DE - B1 - 2 525 132</u> (SIEMENS AG) * column 1, line 54 to column 2 *	6,7	
			CATEGORY OF CITED DOCUMENTS
			X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons
<input checked="" type="checkbox"/> The present search report has been drawn up for all claims			&: member of the same patent family, corresponding document
Place of search Berlin		Date of completion of the search 24-06-1982	Examiner BOTTERILL